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EFFECT OF NEAR AND FAR FIELD RECORDS ON SEISMIC FRAGILITY OF INDUSTRIAL CHIMNEYS

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As a critical component of industrial plants the acceptable seismic performance of chimneys during strong earthquakes is important. The structure has been studied by the previous researchers to investigate the nonlinear behavior during earthquakes, probabilistic seismic vulnerability and collapse mechanism (Wilson et al., 2003; Changdong Zhou et al., 2014; Huang et al., 2004). Openings in the structure have shown to increase the seismic vulnerability. Collapsing the 115 m high chimney in Tupras refinery during the 1999 Kocaeli earthquake, several researches was performed to investigate the seismic performance of this type of structures in earthquakes (Huang et al., 2004; Sezen and Whittaker, 2004).

In this study, calculating the seismic fragility values, the effects of openings as well as the seismic source distance from the site will be studied on the nonlinear behavior and vulnerability of a RC chimney model. A finite element model was developed based on the specifications of the chimney in Tupras refinery provided by Huang et al. (2004). The external diameters of the structure are 10.3 m and 6.6 m in the lowest and highest level, respectively. The dimensions of the section of at the lowest and highest level of the structure as well as an elevation view are presented in Figure 1. 14 near-field and 14 far-field ground motion records were applied in the study to perform Incremental Dynamic Analysis (IDA). Four performance criteria were considered in order to estimate the fragility values as introduced in Table 2.

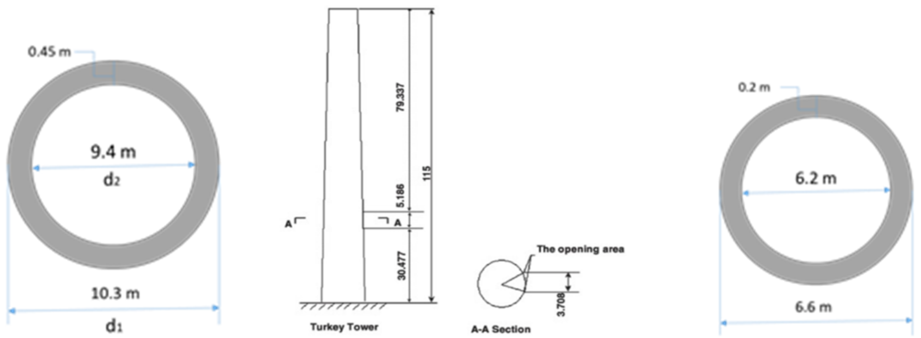


Figure 1. The section views at the lowest and highest level of the structure and the elevation view.

Table 1. Section reinforcement.

Height (m)	Internal Vertical Reinforcement	External Vertical Reinforcement	Internal Lateral reinforcement	External Lateral Reinforcement
115	75Φ10	98Φ10		
90	84Φ18	110Φ15	Φ10@25 cm	Φ12@25 cm
50	118Φ24	136Φ26	Φ10@25 cm	Φ12@25 cm
10	142Φ26	196Φ26	Φ12@25 cm	Φ14@25 cm
0	210Φ26	273Φ26	Φ14@25 cm	Φ16@25 cm

In the current work the threshold strain values of rebar and concrete material are considered as the damage indices to characterize the aforementioned damage states. The steel and concrete strain employed for the quantification of each defined LS is based on previous studies (Lu et al., 2005).

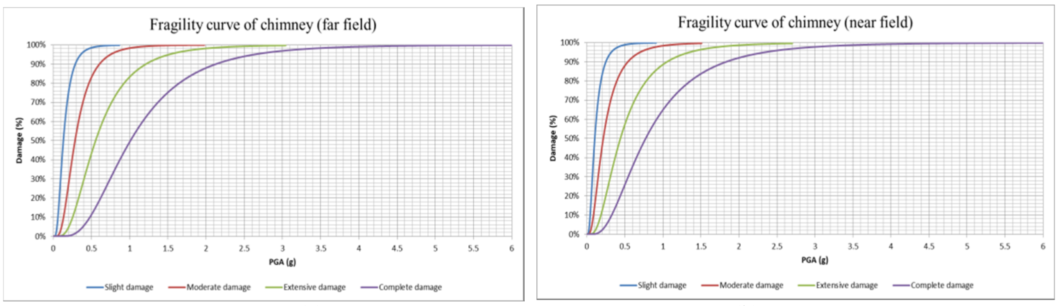
Table 2. Performance criteria considered for the evaluation of fragility values.

Limit state (LS)	Steel strain	Concrete strain	Top displacement threshold values (m)
LS1	0.001675	0.0020	0.08
LS2	0.015	0.0035	0.18
LS3	0.030	0.0050	0.35
LS3	0.060	0.0075	0.62

Defined as Equation 1, the fragility function is estimated as a distribution log-normal function.

$$P[EDP \geq LS_i|IM] = \Phi\left[\frac{\ln(IM)-\lambda}{\xi}\right] \quad (1)$$

where Φ represents standard cumulative normal distribution function and λ and ζ are the mean and standard deviation of natural logarithm of the ground motion intensity (ln(IM)), respectively. The generated seismic fragility curves for the studied RC chimney are shown in Figure 2. It can be observed that larger fragility values have resulted when considering near field ground motions. This may be attributed to the long period component in the records.



(a) (b)

Figure 2. Seismic fragility curve for: a) far-field ground motion records, b) Near field ground records.

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